

In a final Section IV, under the heading "Miscellaneous Papers," with an introduction by R. G. K. Lempert, are grouped those contributions that could not be placed in any of the three larger classifications. Of chief interest, perhaps, are "The Element of Chance Applied to Various Meteorological Problems" and "Climate."

This book is published, as a memorial, by the Royal Meteorological Society. There is a preface by the chairman of the committee, Sir Richard Gregory, and an

appreciative tribute by Dines's close friend and coworker, Sir Napier Shaw. Since Dines did not write a book embodying the results of his researches, it is particularly fitting that his contributions to meteorological science, all of them interesting, many of them of permanent value, should be available in one place for the benefit of investigators in this field. Meteorologists generally are indebted and grateful to the Royal Meteorological Society for bringing this about.

A CONTRAST IN THUNDERSTORMS

By W. J. HUMPHREYS

Every one recognizes this contrast as soon as it is mentioned, but no one says anything about it. At any rate it is not generally stressed. The contrast is this: One class of thunderstorms can not develop *without* wind; another class can not develop *with* wind. Promotion of either is prevention of the other.

Vigorous vertical convection of air rich in water vapor is essential to the genesis of any and every thunderstorm. This convection may be mechanically caused, as by a high mountain ridge across the course of the wind, or by cooler air in the path of warmer, the condition along the warm front of a cyclone. More commonly, however, it results from instability induced by cooling above or heating below, or a combination of both. The cooling above is owing chiefly to the importation of relatively cold air, accentuated more or less, especially at night when cloudy, by radiation. The heating below, on the contrary, usually is produced by sunshine, though in some cases importation of warm air is its major if not sole origin.

Two of the great causes of thunderstorms, therefore, are, (a) cooling above by the importation of cold air, and (b) warming below by insolation. The first is the "cold front" or squall-line thunderstorm, of which there are two classes, the entrapped and the driven; the second, the well-known "heat" thunderstorm. The squall-line storm is induced by a great mass of relatively cold air moving rapidly forward into or crowding against comparatively warm air. Since the velocity of the cold air is much less near the surface than it is at considerable heights, it follows that when the difference in temperature is rather small isolated masses of the warmer air are continually being entrapped by the far overrunning wedge of cooler air, and thereby forced to ascend more or less vigorously.

Some of these ascending masses develop thunderstorms. Other squall thunderstorms are caused by the forced ascent of the warm air immediately ahead of the blunt front of the oncoming relatively quite cold air. In none of these cases can the warm air be entrapped or driven to a strenuous convection in front of the cold tip in the free air, except when that cold air is moving forward speedily. If it were moving very slowly it would just spread out gently beneath the warmer air, entrapping none of it, nor compelling a vigorous uprush anywhere. Hence this abundant and impressive class of thunderstorm, induced by cooling above, is caused by winds. A calm would prevent its formation—it can not occur in still air.

The heat thunderstorm, on the other hand, induced by insolation, must have rather quiet air for its genesis. It grows up from small to larger and larger convections of warm air from the surface. To be effective the chimney of warm air thus formed must remain intact and more or less vertical even though it may wander away to a greater or less distance horizontally. Obviously, however, it could neither remain vertical, if formed, nor intact in air that has any considerable horizontal velocity—could not remain vertical because the velocity of every wind varies with height, nor intact because every wind is turbulent, especially in its lower layers.

In short, and in general, thunderstorms incident to cooling above occur only in winds and never in calms, while those incident to heating below form only in calms and never in winds. And these are the greatest classes of thunderstorms—the wind-hatched and the calm-brooded.

BIBLIOGRAPHY

C. FITZHUGH TALMAN, in Charge of Library

RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Air conditioning engineers handbook. Chicago. [c1932.] v. p. illus. 24½ cm.

American road builders' association.

Snow removal and equipment. Washington. 1931. 20 p. illus. 22½ cm. (Bulletin no. 20.)

Duninowski, André Ike.

Nouvelle méthode de dosage optique de l'ozone atmosphérique. [Montpellier. 1932.] 57 p. pl. (fold.) 22½ cm. (These Univ. Montpellier. These no. 11.)

Eredia, F.

La climatologia dell'alta atmosfera. 7 p. 23½ cm. (Boll. Com. naz. ital. geod. e la geof. 2a. ser. Anno II. N. 4. Apr. 1932. X.)

Gruner, P.

Anwendung der Optik trüber Medien auf die Beleuchtung der Atmosphäre. 1. Die Beleuchtung der idealen Atmosphäre im Sonnenvertikal bei Sonnenuntergang und während der bürgerlichen Dämmerung. 2. Vereinfachte Ausdrücke zur Berechnung der Helligkeit der Atmosphäre. p. 31-58: 145-160. figs. 23 cm. (Helvetica phys. acta. v. 5, fasc. 1, 3.)

India. Meteorological dept.

Meteorological organization in India for the supply of weather information to aviators. Calcutta. 1932. 27 p. pl. (fold.) 25 cm.

International geodetic and geophysical union. Section of meteorology.

Quatrième assemblée générale, Stockholm—août 1930. Procès-verbaux des séances . . . I. Actes de la section. Paris. 1931. 67 p. 25 cm.

International meteorological organization.

Offices météorologiques du monde avec leurs directeurs et états-major, l'attribution de service et leurs publications. Ed. 1932. Utrecht. 1932. 99 p. 25 cm. (Sec. de l'Organ. met. internat. No. 2.)